Ongoing DLR Research on Alternative Fuels and Aviation Emissions

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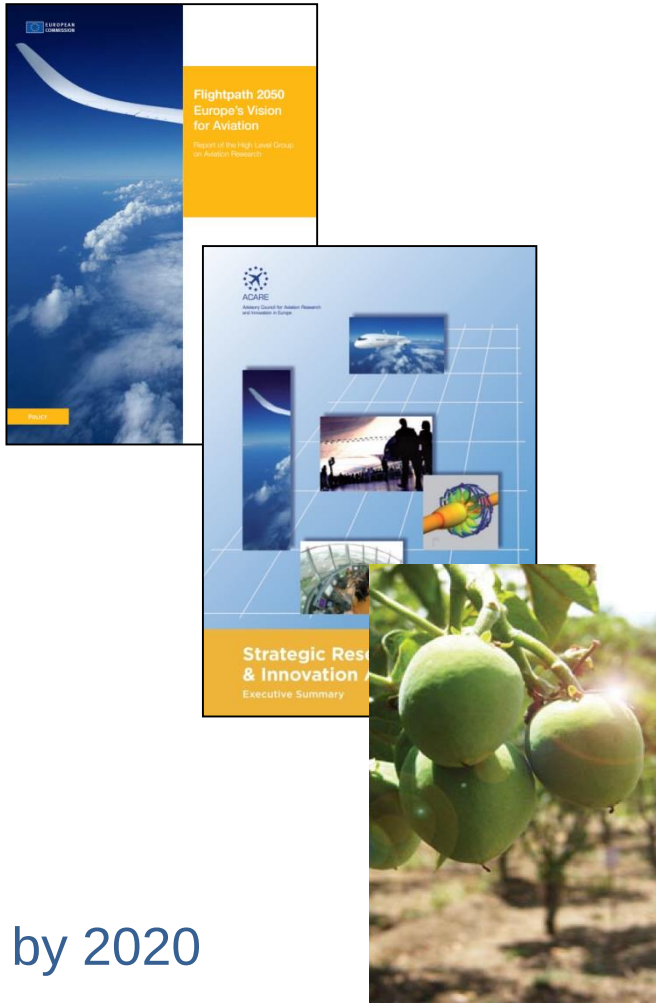
DLR-Institute of Atmospheric Physics

ACCESS-II Workshop
Kissimmee, FL, USA
10 Jan. 2015

Europe's Vision for Environmentally Compatible Development of Aviation



EU Flightpath 2050:

Key Challenge: Protecting the environment & securing energy supply

ACARE Targets 2050:

- Establishment of sustainable alternative fuels (share 2% in 2020, 25% in 2035, 40% in 2050)

EU Advanced Biofuels Flightpath Initiative

Promote production, distribution, storage, and use of biofuels

Goal: 2 million tons of biofuel are used in the EU by 2020 in the aviation sector

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Ongoing DLR Projects

ECLIF (2014-2018):
Emissions and Climate Impact of Alternative Fuel

WeCare (2013-2017):
Mitigation of non-CO_2 climate effects of aviation, incl. studies of cirrus clouds originating from contrails and soot

Future Fuels (2015-2017):
Alternative liquid energy for electrical power production and global transport

ECLIF: Emissions and Climate Impact of Alternative Fuel

Coordination: Patrick Le Clercq

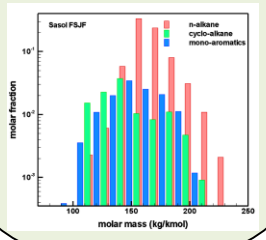
Alternative Fuel Impact on Emissions & Climate

Combustion Chamber Parameters

Engine Parameters

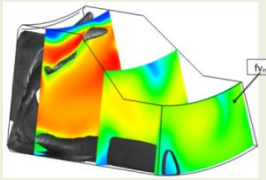
WP 1000

Fuel



WP 2000

Combustion

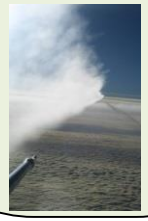


WP 3000

Engine

WP 4000

Emissions measurements



WP 5000

Atmosphere

Fuel Properties

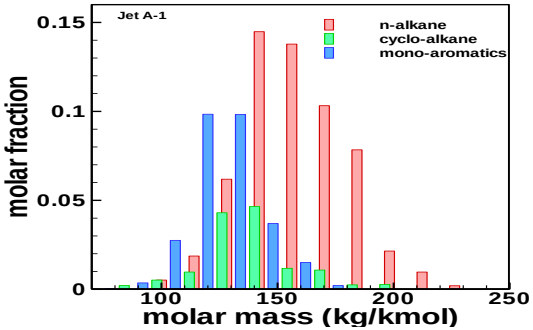
Detailed Emissions

Data

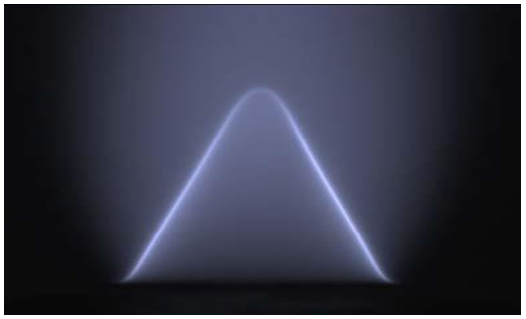
Data

Flight missions

Fuel Properties

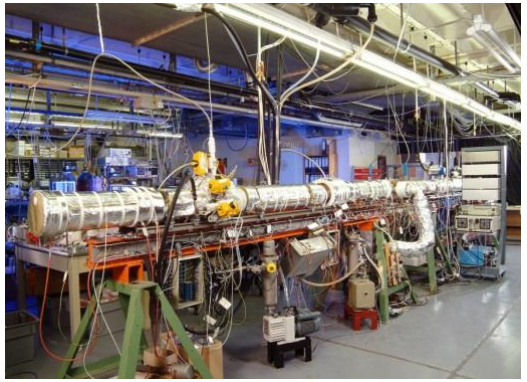


Thermo-physical and thermo-chemical characterization of fuels –
Jet A-1 > Drop-in alt. fuels > Near-Drop-in alt. fuels



Experiments:

- Characterization of fuel composition
- Measurement of characteristic fuel properties (Distillation curve, Smoke Point, Density, etc.)
- Measurement of ignition-delay time and flame speed



Model development:

- Comprehensive reaction models based on these experimental data
- Modeling of thermo-physical and thermo-chemical properties

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Laboratory Measurements

Detailed measurements of fuel effects on combustion behavior and emissions

Use of an optically accessible generic gas turbine combustor

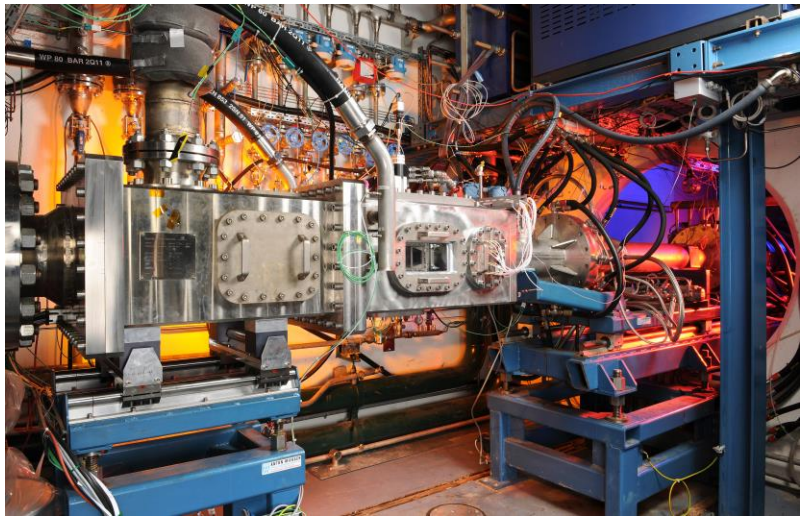
Characteristics

- Fuel mass flow 2 - 5 kg/hour
- Air volume flow 400 – 800 l/min
- Air pre-heat up to 473K
- Pre-filmer airblast atomizer

Diagnostics

- PIV (innert)
- OH-LIF and formaldehyde-LIF
- Spray Characteristics (PDA, SLIPI)
- Chemiluminescence
- LII & emissions at outlet (probe)

Rig Testing



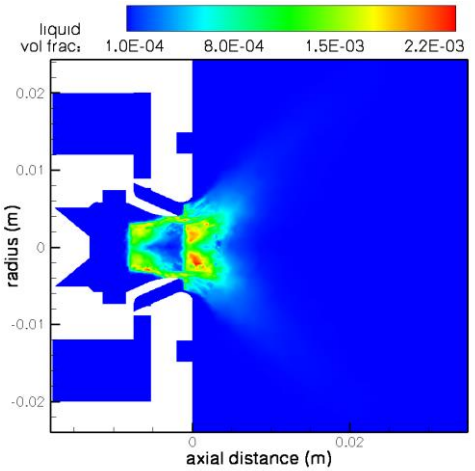
- RQL medium – including cruise – pressure multisector with optical access is operated in cooperation with Rolls-Royce Germany
- Comparison of soot concentration in the combustor (production) with concentration and number at exit (oxidation).
- Laser induced incandescence (LII) within the combustor smoke-meter & SMPS at combustor exit.
- Results incorporated in emissions modeling

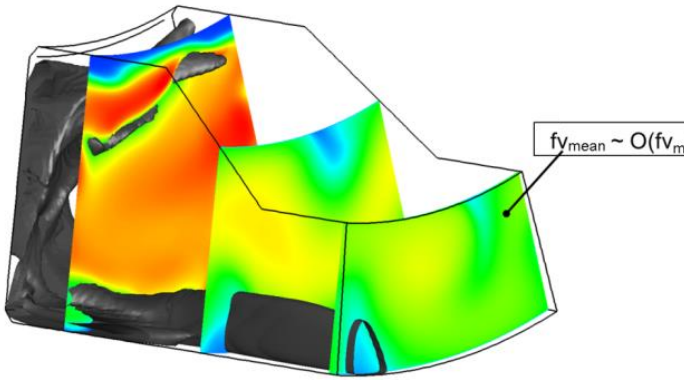
Emission Modeling

Numerical analysis and prediction of fuel effects on combustion behavior and emissions

Detailed simulation of combustion chamber processes including emissions

- Model with multi-species reaction mechanism
- Implementation of reduced mechanisms for target alternative fuels
- Transfer of detailed findings for lab-scale combustion chambers to large-scale combustion systems





Atmospheric Measurements

Comprehensive flight tests:

- Primary emissions and initial contrails (near field, plume age 0.5-2 s)

- Aged contrails (far field, plume age 1-5 min)

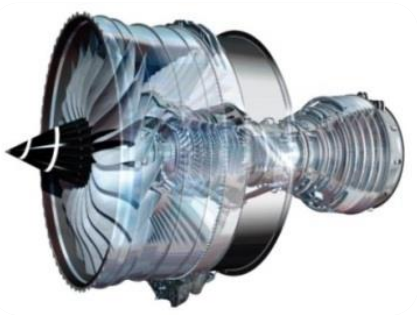
Ground tests: after each flight

Fuels: 5 different FT fuels + HEFA

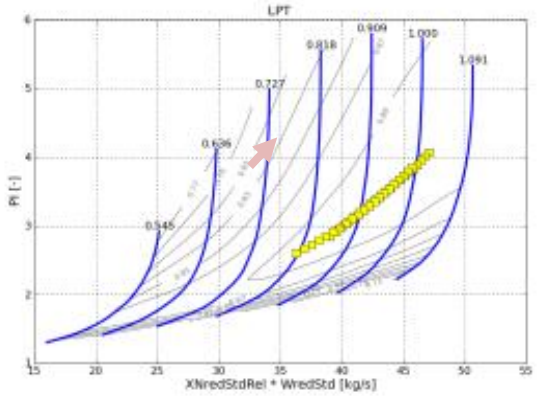
Campaigns: 2015, 2016

Base: previous DLR campaigns and ACCESS-II

Engine Performance, Flight Mission and Global Emissons Simulations



- Alternative fuel engine performance predictions

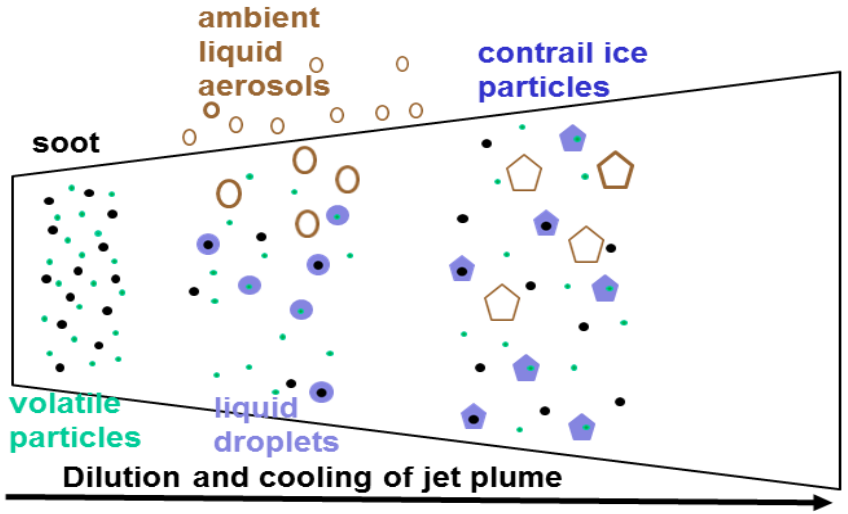


- Prediction of emissions at different flight altitudes and operating conditions (adaption of correlation methods)

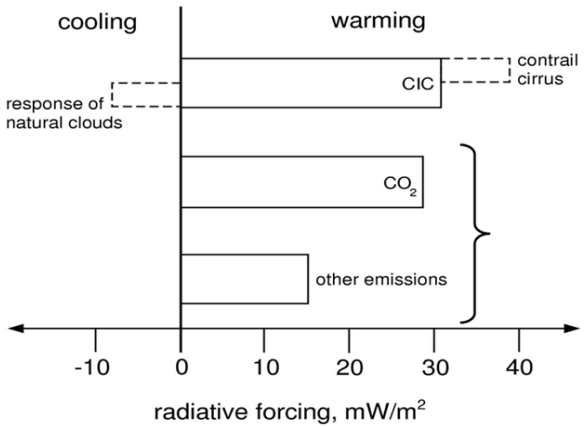
- Calculations of global emissions

Process Studies and Global Modeling of Contrails and their Climate Impact

- Plume processing and contrail formation



- Global modeling of contrail cirrus and their radiative effect



Radiative forcing due to air traffic

ECLIF-I Measurement Campaign
14 Sept. 2015 – 02 Oct. 2015, Germany

ECLIF-II Measurement Campaign
Autumn 2016, Germany

Cooperation:
DLR-Institute of Atmospheric Physics
DLR-Institute of Combustion Technique
DLR-Institute of Propulsion Technique
NASA Langley Research Center
NRC Canada
IFAR - Partners